The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by Elektor Electronics or its consultants.

BASH® IC Amplifier

an entirely new concept

By utilising a special processor and a variable step-down converter, STMicroelectronics in partnership with Indigo Manufacturing have succeeded in developing an integrated amplifier with remarkably high efficiency, without sacrificing audio quality.

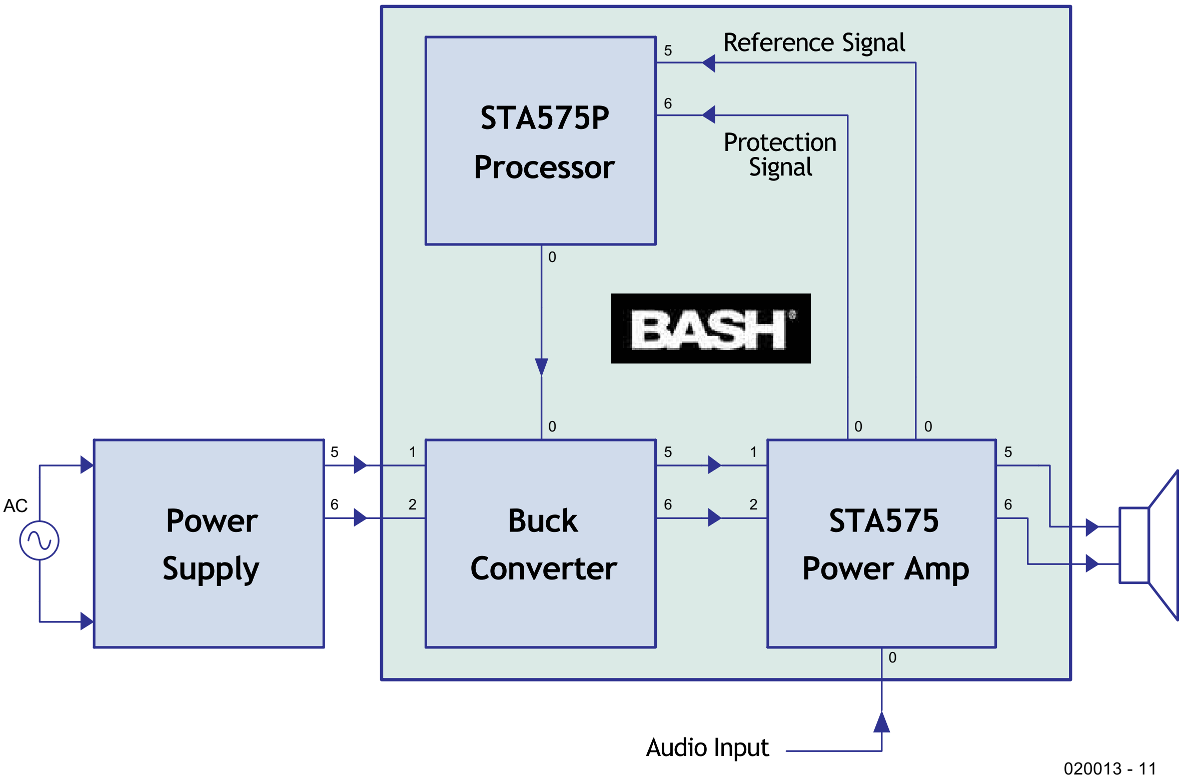

Figure 1. Block diagram of the BASH principle.

Audio enthusiasts are likely to have widely varying opinions on many different subjects, but they are also likely to agree on one thing. If they had the choice, they would prefer an amplifier that delivers perfect quality, is able to deliver quite a bit of power, and is physically as small as possible.

This combination of characteristics is difficult to obtain in practice. Quality and power can be simultaneously realised. But a quality amplifier demands a sizeable power supply and a generous quiescent current in a Class AB design, for example (not to mention Class-A). This all adds up to considerable heat generation that has to be disposed of using an adequately sized heatsink. Such an implementation is not particularly compact.

Power and compactness are two characteristics that can be realised at the same time relatively easily. But this is only possible with frugal quiescent currents (Class B for example), and the subsequent trade-off of reduced quality. This is not an ideal compromise either.

The middle ground is taken by the so-called Class D design which is based on pulsewidth modulation. The inherent disadvantage of Class D is the extensive filtering required at the output of the power switching stage, as well as the strong interference caused by the switching itself. The total power loss is much reduced. It is an excellent system, but here, the weak point is that this switching leads to interference, which adversely influences the characteristics of the amplifier.

It will have become obvious from this discussion that the ideal combination of power, quality and efficiency has not been achieved yet. The engineers at ST have revisited all these topics once more in order to develop a new concept for the company Indigo Manufacturing. And they have indeed succeeded in realising a design with a significant improvement in efficiency without compromising the quality.

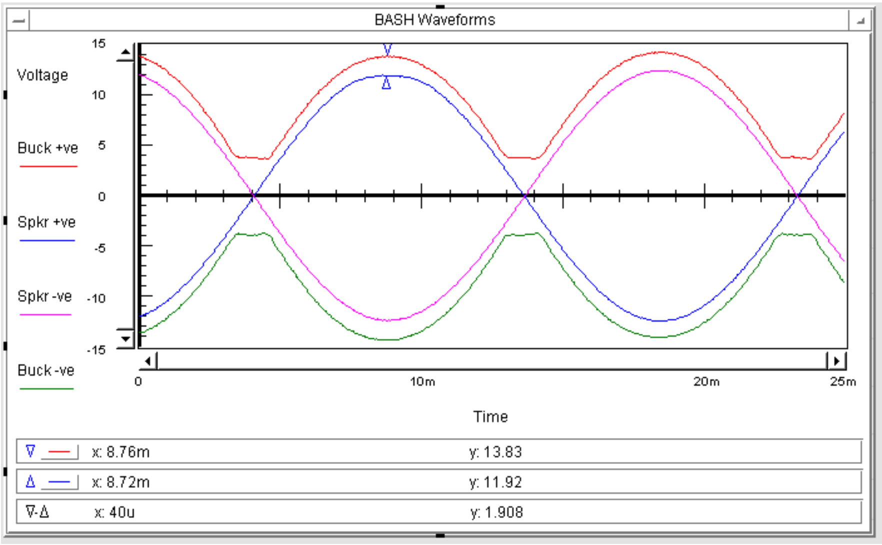

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Figure 2. With BASH, the voltage drop across the power stage transistors remains constant, independent of the output amplitude.

BASH

The only way to improve the efficiency is to, one way or another, vary the power supply voltage depending on the output amplitude of the amplifier. This way, unnecessary dissipation can be avoided. The difference here is that the designers were looking for a way to achieve this without switching, because this would inevitably lead to distortion.

Figure 1 shows the block diagram of the design they arrived at. We can see that besides the usual power supply and power amplifier, two additional blocks have been added: a processor and a buck (step-down) converter.

A reference signal is derived from the power amplifier stage (the 'BASH signal') and applied to the processor. The processor analyses the signal and accurately calculates the demands this signal places on the power supply. This is the basis for generating the gate-drive signal for the step-down converter.

The converter, connected in series with the unregulated power supply, translates this gate signal into an appropriate supply voltage for the power amplifier stage. By continually adjusting the power supply voltage, depending on the amplitude of the amplified audio signal, a constant voltage drop has been achieved across the output transistors, completely independent of the output amplitude. This effect is shown in **Figure 2**.

The result is that unnecessary dissipation has been avoided even though a linear Class AB design is used as the power stage. The efficiency thus obtained is around 85% and is comparable to a Class D amplifier, but the amount of interference is considerably lower. As a consequence, the designers claim that the distortion of a BASH amplifier can be as

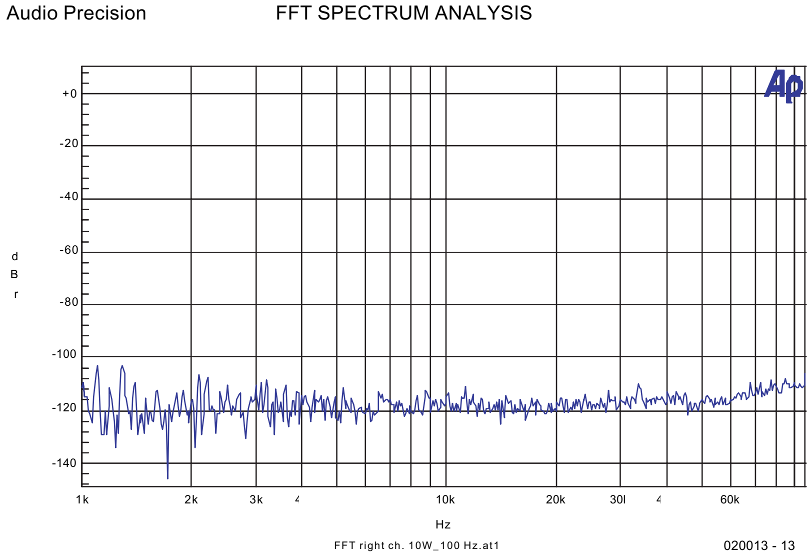


Figure 3. In contrast to a Class D amplifier, no switching artefacts are visible in the output spectrum of the BASH design.

low as that of any other arbitrary Class AB amplifier.

The graph of Figure 3 shows the results of an FFT spectrum analysis of the BASH output signal. It is obvious that this spectrum contains no recognisable switching artefacts.

Another advantage of this BASH system that must not go unmentioned, is the fact that in a multiple channel installation it is possible to have only one power supply and one step-down converter, if that is desired.

Amplifier Modules

Three different BASH amplifier modules have been announced: two stereo versions with output powers of 2 × 50 W en 2 × 75 W (the STA550 and STA575 respectively) and one mono bridge amplifier that can deliver 150W (the STA5150). They are all three identical in design, so for the example we will limit ourselves to the description of the STA575. **Figure 4** shows the block diagram for the circuitry inside the IC amplifier.

Most blocks are powered by means of a fixed positive and negative power supply voltage. Only the power stages are supplied by two external voltages that follow the audio signal.

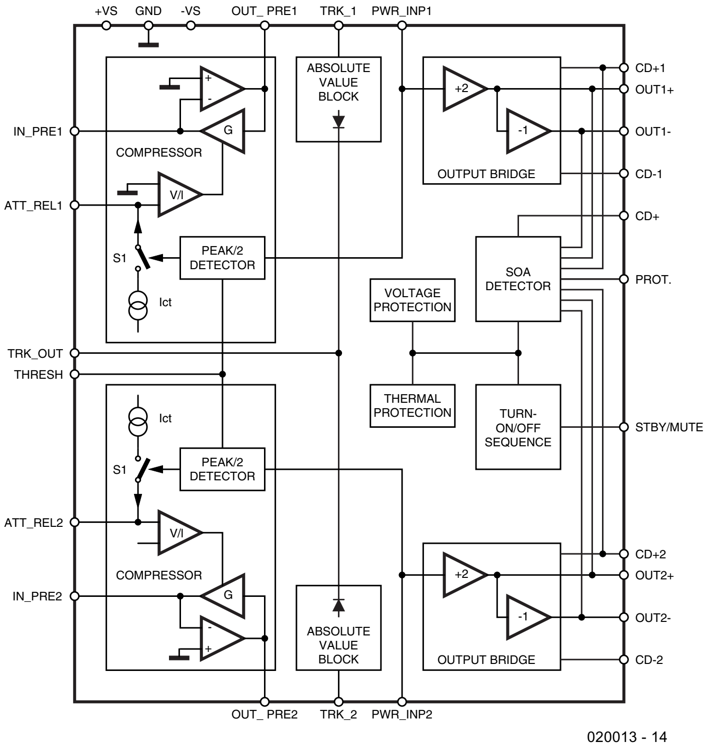
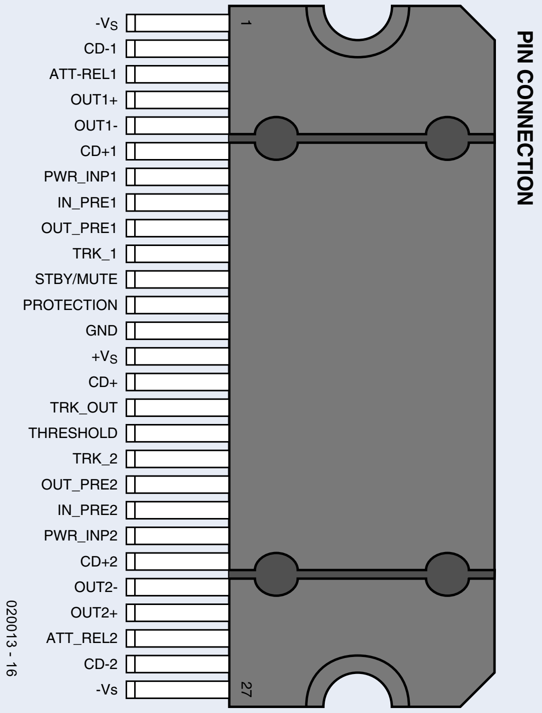


Figure 4. Block diagram for the internal circuitry of the amplifier module, in this case the STA575 which is able to deliver 2 × 75 W.

Table 1. Connections to the STA550/575

Pin-number	Name	Description
1	-Vs	negative bias power supply
2	CD-1	channel 1, variable negative power supply
3	Att Rel1	attack/release channel 1
4	Out1+	channel 1, loudspeaker output positive
5	Out1-	channel 1, loudspeaker output negative
6	CD+1	channel 1, positive power supply
7	Pwr Inp1	channel 1, power stage input
8	In pre1	channel 1, pre-amp input (virtual ground)
9	Out pre1	channel 1, pre-amp output
10	Trk 1	channel 1, absolute-value-block input
11	Stby/mute	standby/mute-control voltage
12	Protection	protection signal for STABP01 digital processor
13	Gnd	analogue ground
14	+Vs	positive bias power supply
15	CD+	variable positive power supply
16	Trk out	reference output for STABP01 digital processor
17	Threshold	compressor threshold input
18	Trk 2	channel 2, absolute-value-block input
19	Out pre2	channel 2, pre-amp output
20	In pre2	channel 2, pre-amp input (virtual ground)
21	Pwr Inp2	channel 2, power stage input
22	CD+2	channel 2, positive power supply
23	Out2-	channel 2, loudspeaker output negative
24	Out2+	channel 2, loudspeaker output positive
25	Att Rel2	attack/release channel 2
26	CD-2	channel 2, variable negative power supply
27	-Vs	negative bias power supply



Each channel has a compressor circuit with a special transfer function. Its purpose is to avoid any dynamic limitations that may be present in the BASH-system. In order to make the system as general-purpose as possible, the attack and release times of the threshold levels are externally programmable. The tracking signal for the external digital step-down converter is generated by the 'absolute value block', which rectifies the output from the compressor. The outputs from these stages are decoupled with a diode to simplify the summing of these signals in a multiple channel amplifier.

The power stages are fitted with a special output pin in order to make AC decoupling possible. This is done so that any DC offset at the compressor output can be eliminated. The power stage has a voltage gain of 4 (+12 dB).

An ingenious circuit functions as the power sensor for the transistors in the power stage and, together with the external converter, provides the intended reduction of the power supply voltage. In addition, there is also a current limit circuit and a temperature sensor to protect the IC itself. Moreover, with an external voltage on the STBY/MUTE pin, both amplifiers can be placed in mute mode, which guarantees on- and off-switching without spurious noises.

The power amplifier ICs are housed in a 27-pin, so-called, Flexiwatt27 package; **Table 1** shows the pin-out for both stereo versions. The mono version is practically pin compatible, only in this case pins 18 through 21 and 25 are not connected.

Digital processor

The block 'processor' in **Figure 1** is implemented with the specially designed STABP01. This is a digital processor with the specific purpose of driving the digital step-down converter. So a BASH amplifier can only be realised with this particular processor.

Figure 5 shows a simplified block diagram for the internals of the STABP01. The manufacturer is still reluctant to divulge too many details. The details of its operation are limited to the information that the processor determines the characteristics of the audio signal and because of this determines the driving signal for the step-down converter. Exactly how this is achieved is not mentioned in any of the documentation. There are a few recognisable details in **Figure 5**, of course, but not the entire approach. An additional comment states that the converter changes the pulse signal into a corresponding power supply voltage for the power amplifier stage, but we already knew that. We also knew already that the processor forms an essential part of the feedback system, where the power supply level of the power amplifier is continually adjusted, based on the instantaneous value of the audio signal. Detailed information, as stated before, is not available yet. Hopefully they will soon reveal some more practical information and provide a detailed application example, because if the BASH system delivers what it promises, it is interesting enough to be thoroughly examined in detail.

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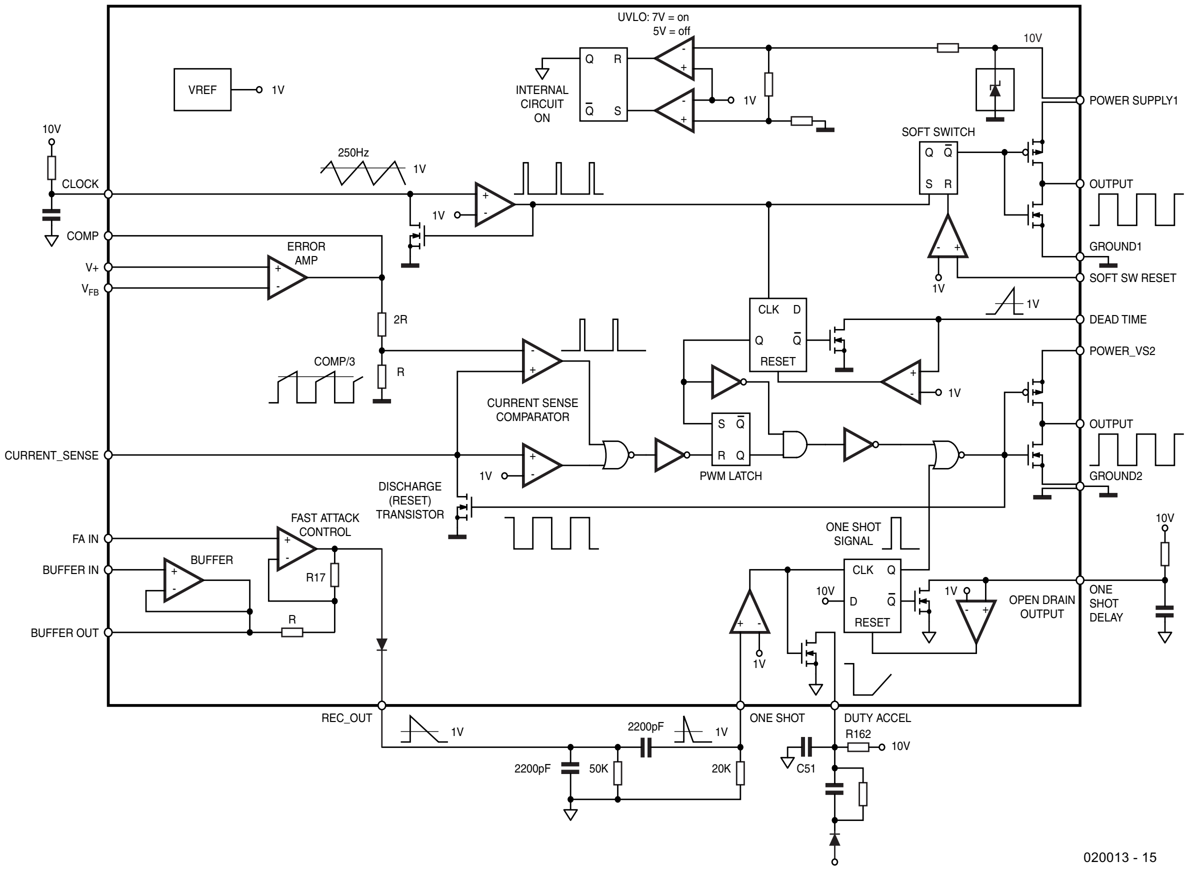

Figure 5. Block diagram of the digital BASH processor STABP01.